Application of Fuzzy Logic for Modeling the Control System of the Technological Parameters of the Main Gas Pipeline

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ABSTRACT

The article discusses the issues of creating an algorithm for controlling the technological parameters of the main gas pipeline - pressure and gas flow using a fuzzy controller, the relevance of solving the problem of creating automatic control systems using intelligent control automation technologies and monitoring technological parameters. For fuzzification by the magnitude of the deviation of pressure and gas flow in the pipeline, the authors presented an algorithm for regulating pressure and flow, and also proposed to use the trapezoidal form of membership functions for three terms and compiled a base of rules. According to the authors, the use of a control algorithm based on fuzzy logic makes it possible to better adapt to the variable operating mode of the gas pipeline and does not require constant selection of the controller coefficients.

Keywords: fuzzy logic, gas pipeline, gas transport, regulation, pressure, flow rate, non- stationarity

Introduction

Recent events taking place in the world have once again proved that natural gas is the main raw material for energy in the world and there is a steady increase in demand for this raw material on world markets. This trend leads to accelerated development and implementation of energy saving and gas consumption optimization programs. As in other countries of the world, so in Uzbekistan, the demand for gas is characterized by seasonal unevenness. The decrease in natural gas consumption in the industrial and socio-economic sectors of the country's economy is observed mainly in the spring and summer periods. In this aspect, the tasks of optimizing gas storage in gas storages deserve attention, the main gas pipeline through which gas is transported , gas - distribution stations (GDS) and control and distribution points (KRP) .

In long trunk gas transport systems , the nonstationarity of processes can have a significant effect. It is mainly due to the uneven nature of gas consumption , switching at complex gas treatment units, repair work and other switching in the interfield reservoir scheme.

The use of only stationary models in the decision-making process leads to significant errors, degrades the effectiveness of the applied solutions, and only to a small extent covers the range of tasks solved by the dispatching service. Therefore, there is a need to create simulation and optimization models for making decisions on the control and management of the non-stationary process of gas transportation .

It happens sometimes that fluctuations in pressure, flow and temperature over time are very small and the non-stationarity of the system mode can be represented as a fuzzy state of the process and set by the corresponding membership functions. But if the degree of non-stationarity of the process is huge, then it becomes necessary to use formulas for non-stationary gas transport as a model of a linear section.

Materials

The state of the gas transportation system is described by the following variables, which completely determine its state - gas flow rate q , temperature T and pressure p at the inlet and outlet of the element:

$\bar{z}$=($p_{вх}$, $T_{вх}$, $q_{вх}$, $p_{вых}$, $T_{вых}$, $q_{вых}$)

In the absence of gas consumption and other costs within the system, that is, when the gas flow along the main line is stationary e $q_{вх} = q_{вых}$. The elements of the main gas transportation system are gas compressor units (GPA), GDS, CRP and linear sections (LU), from which more complex systems can be formed. However, these more complex systems will also be uniquely characterized by a state vector.

The need to consider the main line as a multi-level, multi-purpose, as well as the presence of various types of uncertainty in the system led to the creation of a new algorithm based on the theory of multi-level hierarchical systems and the theory of fuzzy sets.

When the decision-making process for the control of such technological and facility is carried out by the operator, it becomes necessary to model this decision and evaluate its accuracy and efficiency. Modeling can be carried out using fuzzy set theory.

Methods

Before designing a system, it is necessary to determine the base of fuzzy rules. The following are the variables taken into account when compiling the base of fuzzy rules.

1) linguistic variables of temperature: small, medium, large;
2) linguistic pressure variables: small, medium, large;
3) linguistic variables of consumption: very small, small, medium, large, very large.

The following are the fuzzy rules:

Rule 1: IF temperature = low AND pressure = low, THEN flow = very low;
Rule 2: IF temperature = low AND pressure = medium, THEN flow = low;
Rule 3: IF temperature = medium AND pressure = low, THEN flow = medium;
Rule 4: IF temperature = medium AND pressure = medium THEN flow = medium;
Rule 5: IF temperature = medium AND pressure = high, flow = high;
Rule 6: IF temperature = high AND pressure = medium, THEN flow = high;
Rule 7: IF temperature = high AND pressure = low THEN flow = very high.

Next, you should choose the form of fuzzy sets and determine the range of acceptable values. For example, valid values for the variable "Temperature" are in the range [0, 6 0] degrees , " Pressure " in the range [0, 3] MPa, " Flow " in the range [0, 4] million cubic meters .

For both input linguistic variables, the trapezoidal form of fuzzy sets was chosen. When designing, the Fuzzy expansion package was used logic Toolbox for MATLAB software.

fuzzy logic controller is a linguistic model of the strategy of a human operator and can thus serve as a model of a decision block.

Conclusion

Fuzzy algorithms can be used to control the non-stationary process of gas production and transportation, as well as to control the process of natural gas preparation. To control this process, the use of fuzzy algorithms is especially effective, since the absence of sensors for measuring a number of parameters, according to the value of which decisions are made (for example, on the consumption of diethylene glycol), leads to the fact that the input values are estimated using analytical sensors approximately and, in fact, are fuzzy.

Comparison of the results of direct digital control and fuzzy control, carried out in many works on the application of the theory of fuzzy sets, showed that fuzzy control is simpler and more efficient than commonly used classical methods.

References

1. Altunin A.E., Semukhin M.V. Models and algorithms of acceptance solutions in fuzzy conditions : Monografiya . Tyumen: Publishers Tyumenskogo State University, 2000. - 352p .
2. Guest B . I . Fuzzy regulators _ in x system automatic management / V . I . Gostev - K .: " Radiomator ", 2008. - 972 p .
3. Abdukadirov AA, Shomirzaev BU Application Of Fuzzy Logic To Control The Process Of Natural Gas Drying. // The American Journal of Engineering and Technology , USA 2021, Vol. 3, Issue 7, pp.1–8. DOI-10.37547/ tajet (23, SJIF , IF- 5.705)
4. Siddikov IX, Shomirzaev BU Gas Pressure and Flow Control Algorithm in Main Gas Pipelines Using the Fuzzy Logic Apparatus // International journal of advanced research in science, Engineering and technolog *y.* India 2019, Vol. 6, Issue 8, August 2019 (05.00.00; №8)
5. Deepa S. Bhandare , N. R. Kulkarni Design of an Intelligent Pressure Control System Based on the Difuso Self-tuning PID Controller International Journal of R ecent Advances in Engineering & Technology (IJRAET) 2018, Vol. 4, 16-20
6. Shomirzaev BU Analysis of the pressure control system in gas tubes with the use of the fuzzy logic controller // European Journal of Business and Social Sciences , 4th -International Eduindex Multidisciplinary Conference, Switzerland, 2019. –pp.76-81 .
7. Campbell JM Gas conditioning and processing. Volume 1: The Basic principles 9th edition. — John M. Campbell & Co., 2014.
8. Pegat A. Nechetkoe modeling i upravlenie / A. Pegat . – M.: Binom , 2-ye izd ., 2013. – 798 s.